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IS : 10776 ( Part 4 ) - 1984

*Indian Standard*

**METHODS OF MEASUREMENT OF  
ELECTRO-ACOUSTICAL CHARACTERISTICS  
OF HEARING AIDS**

**PART 4 HEARING AIDS WITH BONE VIBRATOR**

UDC 616'28-76 : 534'773'2



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**INDIAN STANDARDS INSTITUTION**  
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG  
NEW DELHI 110002

# Indian Standard

## METHODS OF MEASUREMENT OF ELECTRO-ACOUSTICAL CHARACTERISTICS OF HEARING AIDS

### PART 4 HEARING AIDS WITH BONE VIBRATOR

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Emeritus Scientist  
National Physical Laboratory ( CSIR )  
New Delhi

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( Continued on page 2 )

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## *Indian Standard*

# METHODS OF MEASUREMENT OF ELECTRO-ACOUSTICAL CHARACTERISTICS OF HEARING AIDS

## PART 4 HEARING AIDS WITH BONE VIBRATOR

### 0. FOREWORD

**0.1** This Indian Standard ( Part 4 ) was adopted by the Indian Standards Institution on 16 February 1984, after the draft finalized by the Acoustics Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

**0.2** The majority of hearing aids in use are of air conduction type but a small percentage use a bone vibrator instead of an earphone. The use of a bone vibrator requires a different method of measuring the output from the hearing aid and also makes it impractical to measure amplification directly in terms of acoustic gain.

**0.2.1** Amplification in the case of an air conduction hearing aid is expressed as the difference between the output sound pressure level in an acoustic coupler or ear simulator and the input sound pressure level measured in a specified manner. However, with bone conduction hearing aids, the input is in terms of sound pressure level but the output will be in terms of mechanical vibration measured as an alternating force or force level. This document defines a method of expressing the input/output ratio as an acousto-mechanical sensitivity level measured on mechanical coupler.

**0.3** By means of information provided in this document the performance of hearing aids with bone vibrator outputs which do not form an integral part of the hearing aid, for example, body worn hearing aids, may be measured in a similar manner to aids with air conduction outputs.

**0.3.1** Where the bone vibrator forms an integral part of the hearing aid, or where it is attached in some fixed manner to the hearing aid ( for example, a headband type bone conduction hearing aid ), performance cannot be measured in the same way as for body worn aids, due to the large dimensions of the mechanical coupler having to be in contact with the spectacle arm. This document recommends a pressure method of controlling the input sound level to the hearing aid microphone.

## **IS : 10776 ( Part 4 ) - 1984**

**0.4** The methods described will produce a suitable basis for the exchange of information or for direct comparison of the electro-acoustical characteristics of hearing aids using bone vibrator outputs. These methods are chosen to be practical and reproducible and are based on selected fixed parameters.

**0.4.1** The results obtained by the methods specified herein express the performance under the conditions of the test, but will not necessarily agree exactly with the performance of the hearing aid under practical conditions of use.

**0.5** The methods of measurement of electro-acoustical characteristics of hearing aids as being covered by a series of standards consisting of the following individual parts:

Part 1 General measurements for air-conduction hearing aids

Part 2 Additional measurements for hearing aids with induction pick-up coil input

Part 3 Additional measurements for hearing aids with automatic gain control circuits

Part 4 Measurements of characteristics of hearing aids with bone vibrator outputs.

**0.6** While preparing this standard, assistance has been derived from IEC Doc: 29 ( C. O. ) 133 'Method of measurement of characteristics of hearing aids with bone vibrators', issued by International Electrotechnical Commission.

**0.7** In reporting the result of a test made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960\*.

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## **1. SCOPE**

**1.1** This standard ( Part 4 ) specifies methods of measurement of the characteristics of hearing aids using bone vibrator outputs.

## **2. TERMINOLOGY**

**2.0** For the purpose of this standard, the terms and definitions given in IS : 1885 ( Part 3 /Sec 5 )-1966† shall apply, in addition to the following.

\*Rules for rounding off numerical values ( revised ).

†Electrotechnical vocabulary: Part 3 Acoustics, Section 5 Speech and hearing.



**2.1 Bone Vibrator** — An electromechanical transducer intended to produce the sensation of hearing by vibrating the cranial bones.

**2.2 Mechanical Coupler** — A device designed to present a specified mechanical impedance to a vibrator applied with a specified static force, and equipped with a mechano-electric transducer to determine the alternating force level referred to the surface of contact between vibrator and mechanical coupler.

**2.3 Alternating Force Level ( Force Level )** — Twenty times the logarithm to the base 10 of the ratio of the rms value of the force transmitting the vibration to the reference value of 1 micronewton (  $1 \mu\text{N}$  ), expressed in decibels.

**2.4 Output Force Level ( OFL )** — The alternating force level produced at a specified frequency on a mechanical coupler by the bone vibrator of the hearing aid under test. The abbreviation for this term is OFL.

**2.5 Output Force Level Frequency Response ( Force Level Curve )** — The output force level ( OFL ) produced on the mechanical coupler by the hearing aid expressed as a function of frequency under specified test conditions for constant input sound pressure level.

**2.6 Saturation Force Level** — The highest obtainable output force level obtainable at a specified frequency, regardless of input sound pressure level.

**2.7 Saturation Force Level Curve** — Saturation force level expressed as a function of frequency.

**2.8 Maximum Saturation Force Level** — The highest value on a saturation force level curve.

**2.9 Output Force Level for Input Sound Pressure Level of 90 dB (  $\text{OFL}_{90}$  )** — The output force level at a specified frequency produced with an input sound pressure level of 90 dB and the hearing aid gain control in the full-on position. The abbreviation for this term is  $\text{OFL}_{90}$ .

**2.10 Reference Point ( of a Hearing Aid )** — A point on the hearing aid chosen for the purpose of defining its position, normally the centre of the main sound entry to the aid.

**2.11 Acousto-Mechanical Sensitivity** — At a specified frequency and under specified operating conditions the quotient of the alternating force produced on the mechanical coupler by the hearing aid and the sound pressure at the reference point of the hearing aid.

**2.12 Acousto-Mechanical Sensitivity Level** — Twenty times the logarithm to the base 10 of the ratio of the acousto-mechanical sensitivity to the reference sensitivity of  $\frac{1 \mu\text{N}}{20 \mu\text{Pa}}$  expressed in decibels.

NOTE — To calculate the acousto-mechanical sensitivity level ( AMSL ) from measurements made in this standard the following formula may be used:

AMSL = ( OFL expressed in dB ref 1  $\mu$ Newton ) — ( Sound pressure level to the hearing aid microphone in dB ref 20  $\mu$ Pascal )

AMSL = OFL — INPUT SPL

**2.13 Reference Test Gain Control Position** — The setting of the hearing aid gain control that provides an output force level on the mechanical coupler (  $15 \pm 1$  ) dB less than OFL<sub>90</sub> for an input sound pressure level of 60 dB at the reference test frequency of 1 600 Hz or 2 500 Hz, when appropriate. If the acousto-mechanical sensitivity level available will not permit this, the full on gain control position of the hearing aid shall be used.

**2.14 Basic Force Level Frequency Response** — The output force level frequency response obtained with the gain control in the reference test gain position and with an input SPL of 60 dB.

### **3. GENERAL CONDITIONS FOR MEASUREMENTS**

**3.1** Provisions of 3, 4 and 5 of Part 1\* of this standard shall apply.

### **4. TEST EQUIPMENT**

**4.1 Equipment for the Measurement of Output Force Level** — The equipment used for measurement of output force level on the mechanical coupler produced by the hearing aid, shall comply with the following requirements.

**4.1.1** For all measurements a mechanical coupler in accordance with 'Indian Standard specification on mechanical coupler ( *under preparation* )' shall be used.

**4.1.2** The output indicator used shall give rms indication within a tolerance of  $\pm 0.5$  dB at a signal crest factor of not more than 3.

NOTE — It is well known that the type of output indicator employed may influence the test results significantly if a non-sinusoidal voltage is being measured. Such non-sinusoidal voltages may be present when making measurements with high input levels.

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\*Methods of measurement of electro-acoustical characteristics of hearing aids: Part 1 General measurements for air conduction hearing aids.

**4.1.3** The output force level corresponding to hum, vibration, thermal agitation and other noise sources shall be sufficiently low to ensure that the reading shall drop at least 10 dB when the test signal is switched off.

For this purpose a high-pass filter not affecting frequencies of 200 Hz and above may be employed.

NOTE — Under certain conditions it is necessary to use a selective measuring system in order to ensure that the response of the hearing aid to the signal can be differentiated from unwanted noise. The performance of any selective system used should be stated in the report.

**4.1.4** The overall accuracy of the electronic measuring system following the mechanical coupler shall be within  $\pm 0.5$  dB at a specified frequency.

**4.1.5** The calibration of the mechanical coupler shall be in accordance with 'Indian Standard specification on mechanical coupler (*under preparation*)'.

NOTE — The calibration of the mechanical coupler should be repeated sufficiently often to ensure that it remains within the permitted limits during measurements.

## **4.2 Equipment for Automatic Frequency Recording**

**4.2.1** The equipment shall be capable of maintaining at the test point all requisite sound pressure levels between 50 and 90 dB within such tolerances as specified in 4 of Part I\* of this standard. The indicated frequency on a recorder chart shall be accurate within  $\pm 5$  percent. The automatically recorded values shall not differ by more than 1 dB from the steady state value over the frequency range 200 to 5 000 Hz.

**4.2.2** The automatic recording equipment may be either of the continuous sweep type or of the discrete frequency type ( for example microprocessor type ). In the latter case, a sufficient number of test frequencies shall be used to provide well-defined response curves.

## **5. CONDITIONS FOR TEST**

**5.0** Provision of 5 of Part 1\* of this standard shall apply in addition to the following.

**5.1 Bone Vibrator and Mechanical Coupler** — The bone vibrator and mechanical coupler shall both be brought to the proper operating temperature of  $25 \pm 2$  °C. Deviations of up to  $\pm 5$ °C may be allowed, if the proper operating temperature cannot be achieved, provided that

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\*Methods of measurement of electro-acoustical characteristics of hearing aids; Part 1 General measurements for air-conduction hearing aids,

manufacturer's data for variation of sensitivity of the mechanical coupler with temperature is used to correct any results. Impedance variations however cannot be corrected.

The temperature of the mechanical coupler at the time of test shall be stated.

NOTE — Stringent requirements for the temperature of the mechanical coupler are necessary due to considerable variations in both sensitivity and impedance of the coupler with temperature. As the mass of the mechanical coupler is large, long periods of time for example 24 hours may elapse before its temperature stabilizes.

## 5.2 Locating the Hearing Aid in the Sound Field

**5.2.1 Free Field Measurements** — This method is only applicable to hearing aids with separate bone vibrators. That portion of the hearing aid containing the microphone shall be placed in the sound field in accordance with the test conditions specified in Part 1 of this standard. The Mechanical coupler to measure the output from the bone vibrator shall be situated so as not to influence the sound field at the test point.

**5.2.2 Pressure Measurements** — This method is applicable to any type of bone conduction hearing aid. The sound field at the hearing aid reference as given in 5.2.2.1 point shall be controlled. For hearing aids with separate bone vibrators that part of the aid containing the microphone shall, where possible, be removed from the vicinity of the mechanical coupler.

Figure 1 is an example of an arrangement for controlling the sound field in the case of a hearing aid with an integral bone vibrator.

NOTE — When a controlling microphone is used care should be taken to avoid radiated airborne noise from the bone vibrator affecting that microphone.

### 5.2.2.1 Control of the sound field

- a) *By means of a monitoring microphone* — To achieve adequately constant SPL at the reference point over the required frequency range the distance between the centre of the diaphragm of the monitoring microphone (preferably half-inch) and the reference point of the hearing aid shall be between 5 mm and 10 mm. Hearing aids with directional microphones shall be oriented with direction for maximum sensitivity pointing towards the sound source.

- b ) *With electronic data storage* — An alternative method of keeping the sound pressure level constant is to let the pressure calibrated microphone, 5 mm to 10 mm from the reference point of the hearing aid, measure the SPL at discrete frequencies with the model of hearing aid to be tested in its test position. By suitable means, for instance digital equipment or a tape recorder, store and subsequently reproduce the required voltages for constant SPL at the reference point with either the monitoring microphone still in place or a dummy simulating that microphone in the same place in order to fulfil pressure method conditions.

NOTE — Methods of test that do not keep the monitoring microphone or a dummy in place, may give different results between the methods given in ( a ) and ( b ). Different results may also occur if the sound field is calibrated with a hearing aid other than the model under test in place.

### 5.3 Applying the Bone Vibrator to the Mechanical Coupler

**5.3.1 Locating the Bone Vibrator on the Mechanical Coupler** — The centre of the vibrating surface of the bone vibrator shall coincide with the centre of the mechanical coupler pad. At its centre the vibrating surface shall be perpendicular to the axis of the mechanical coupler.

Figures 1 and 3 show examples of a spectacle aid mounted for test purposes.

Figure 2 is an example of a bone vibrator held in place on the mechanical coupler by its headband.

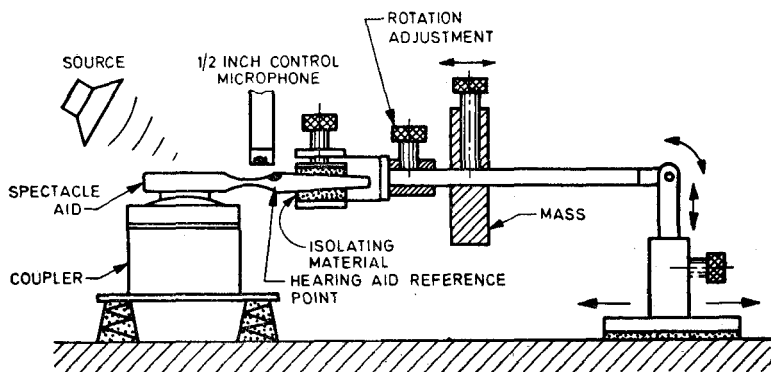


FIG. 1 AN EXAMPLE OF A HEARING AID WITH AN INTEGRAL BONE VIBRATOR UNDER TEST

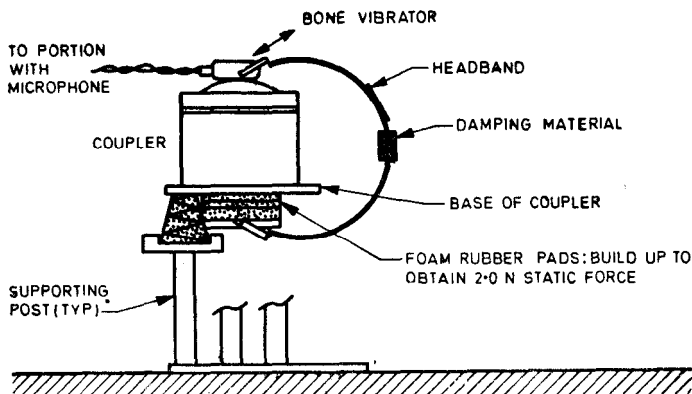


FIG. 2 AN EXAMPLE OF A BONE VIBRATOR WITH HEADBAND MOUNTED IN THE MECHANICAL COUPLER

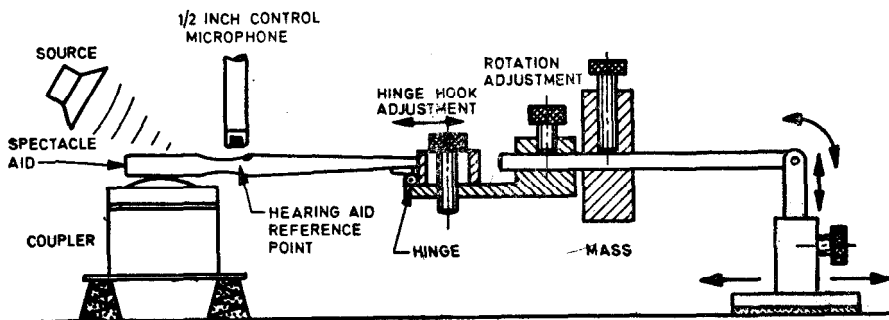


FIG. 3 AN EXAMPLE OF A HEARING AID WITH AN INTEGRAL BONE VIBRATOR UNDER TEST AND HEARING AID TEMPLE ATTACHED TO HINGE

Figure 4 shows an example of a headband type bone conduction hearing aid, mounted for test purposes.

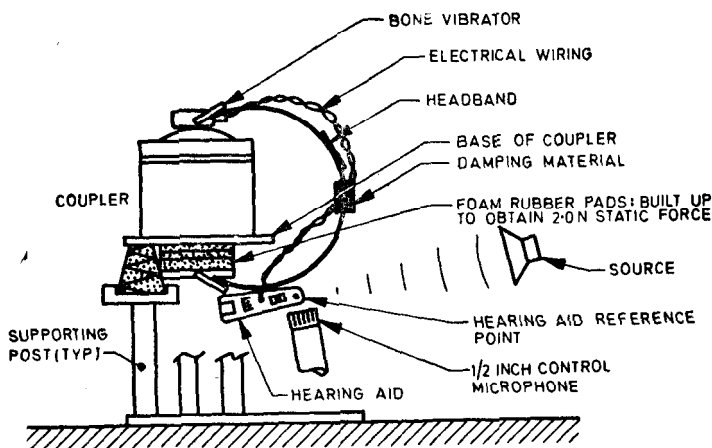


FIG. 4 AN EXAMPLE OF A BONE VIBRATOR WITH HEADBAND MOUNTED ON THE MECHANICAL COUPLER AND AMPLIFIER WITH MICROPHONE PERMANENTLY ATTACHED TO THE HEADBAND

**5.3.2 Static Force** — The bone vibrator shall be applied to the mechanical coupler with a static force of  $2.5 \pm 0.3$  N. The application of the bone vibrator to the mechanical coupler shall not add mass to the vibrator. The static force may be measured using a spring balance, care being taken that the force is measured along a line that coincides with the axis of the mechanical coupler.

## 6. MEASUREMENTS

**6.0** Data shall be quoted for that part of the frequency range between 200 and 5 000 Hz over which the output of the hearing aid falls by at least 10 dB when the signal source is switched off.

**6.1 Output Force Level Curve for an Input SPL of 90 dB (OFL<sub>90</sub> Curve)** (see 2.9).

**6.1.1** The purpose of this test is to determine the frequency response of the OFL obtained on the mechanical coupler when using an input SPL of 90 dB and with the gain control in the full-on position.

**6.1.2 Test Procedure**

**6.1.2.1** Turn the gain control full-on and set other controls to desired positions.

**6.1.2.2** Adjust the input SPL to 90 dB at a suitable frequency.

**6.1.2.3** Vary the frequency of the sound source over the recommended frequency range from 200 to 5 000 Hz keeping the input SPL constant at 90 dB and record the OFL obtained on the mechanical coupler.

NOTE — As output signal at saturation will contain high levels of distortion products, the method of measurement may influence the level measured. If the output signal is measured through a filter centred at the test signal frequency lower levels may result than would be measured using a wide band instrument. It is therefore recommended that only wide band measurements should be made for this purpose. ( see also note below 4.1.3 ).

**6.2 Full-on Force Level Frequency Response ( see 2.5 )**

**6.2.1** The purpose of this test is to determine the full-on acousto-mechanical sensitivity level obtainable from the hearing aid. The OFL on the mechanical coupler is measured at the full-on gain control setting with an input SPL sufficiently low to ensure essentially linear input-output, conditions.

**6.2.2 Test Procedure**

**6.2.2.1** Turn the gain control full on and set each of the other controls to its desired position, preferably to give the widest frequency range.

**6.2.2.2** At a suitable frequency adjust the input SPL to 60 dB or, if this does not produce essentially linear input-output conditions to 50 dB SPL. Essentially linear input-output conditions are considered to exist if at all frequencies within the range 200 to 5 000 Hz a change of the input SPL of 10 dB causes a change of the recorded output force level of  $10 \pm 1$  dB. The input SPL shall be stated.

NOTE — For hearing aids with certain circuit arrangements, for example, push-pull aids, non-linear input-output characteristics may be observed over a large portion of the operating range.

**6.2.2.3** The output force level frequency response with full-on gain is measured by varying the frequency of the sound source over the recommended frequency range 200 to 5 000 Hz keeping the input SPL constant.

**6.2.2.4** The full-on acousto-mechanical sensitivity level is plotted as a function of frequency and may be reported for a specified frequency.



### **6.3 Basic Force Level Frequency Response ( see 2.14 )**

#### **6.3.1 Test Procedure**

**6.3.1.1** Adjust the gain control to the reference Test gain position ( see 2.13 ) and set other controls to desired positions, preferable to give the widest frequency range.

**6.3.1.2** Vary the frequency of the sound source over the recommended frequency range 200 to 5 000 Hz keeping the input SPL constant at 60 dB and plot the OFL in the mechanical coupler as a function of frequency.

### **6.4 Effect of Tone Control Position on the Basic Force Level Frequency Response**

**6.4.1** The purpose of this test is to show the effect of tone control position on the basic force level frequency response of the hearing aid.

#### **6.4.2 Test Procedure**

**6.4.2.1** Adjust the tone control of the hearing aid to that used in the basic position ( see 6.4 ) and set other controls to desired positions.

**6.4.2.2** Adjust the gain control to the reference test gain position ( see 2.13 ).

**6.4.2.3** Vary the frequency of the sound source over the frequency range 200 to 5 000 Hz, keeping the input SPL constant at 60 dB.

**6.4.2.4** Repeat the test with other remaining tone control settings.

**6.4.2.5** The frequency response at the various tone control settings should be plotted together with the basic frequency response in terms of the OFL on the mechanical coupler as a function of frequency.

### **6.5 Battery Current**

**6.5.1** The purpose of this test is to determine the battery current.

**6.5.2** With the gain control in the reference test gain position measure the battery current at the reference test frequency and with an input SPL of 60 dB.

**6.5.3** The direct-current measuring system shall have the following characteristics :

- a) An accuracy of  $\pm 5$  percent at the value of current measured.

- b) A direct current resistance not exceeding  $50/I$ , where  $I$  is the current being measured, in milliamperes.
- c) An alternating current impedance not exceeding 1 ohm over the frequency range 200 to 5 000 Hz.

NOTE — One method of realizing item 3 above is to bypass the current meter with a capacitor of at least 8 000 F. The capacitor should not shunt the battery or power supply.

## **6.6 Non-Linear Distortion**

**6.6.1** Provision of 6.12 of Part I\* of this standard shall apply.

## **6.7 Internal Noise from the Hearing Aid**

**6.7.1** Provision of 6.14 of Part I\* of this standard shall apply.

## **6.8 Characteristics of Hearing Aids with Induction Pick-up Coil Input**

**6.8.1** Provisions of Part 2† of this standard shall apply.

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\*Methods of measurement of electro-acoustical characteristics of hearing aids: Part 1 General measurements for air-conduction hearing aids.

†Methods of measurement of electro-acoustical characteristics of hearing aids: Part 2 Hearing aids with induction pick-up coil input ( *under preparation* ).